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Potential application of seafood-derived peptides as bifunctional ingredients, antioxidant–cryoprotectant: A review

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ABSTRACT

Seafoods have served as a significant source of lipids and proteins for human requirements. However, they are prone to chemical deterioration, especially oxidation and quality loss during storage and processing, associated with the development of off-odours/flavours and loss of nutritive value. Antioxidants have been used widely to prevent lipid oxidation, while cryoprotectants are known to retard protein denaturation of seafoods during the extended frozen storage. Due to possible toxicity and carcinogenic effects of synthetic antioxidants and sweetness of particular cryoprotectant, the natural and safe additives, derived from seafood origin have gained increasing attention. Peptides, mostly derived from processing by-products, have been demonstrated to exhibit antioxidative and cryoprotective effects in seafoods. This article revisits the antioxidative and cryoprotective effects of seafood-derived peptides for their potential as bifunctional ingredients to prevent lipid oxidation and protein denaturation in different seafood systems.

Contents

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1. Introduction

Seafoods contain high amounts of nutritionally important omega 3 (ω3)-polyunsaturated fatty acids (PUFA), mainly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Shahidi & Ambigaipalan, 2015). The high proportion of long chain ω-3 PUFA as well as high amounts of haem pigments and metallic traces like iron and copper is crucial factors making fish muscle prone to lipid oxidation. Oxidation of fish lipids not only produces undesirable odours and flavours, but can also decrease the nutritional quality and safety by the formation of secondary lipid oxidation products (Jacobsen, Nielsen, Jørgensen, & Nielsen, 2010). Furthermore, the reactions occurring between lipid oxidation products and components of fish muscle such as proteins, amino acids, vitamins and cholesterol also bring about degradations or undesirable modifications to these components. These detrimental reactions lead to loss of quality and nutritional value of products (Medina & Pazos, 2010). The oxidised fish is characterised by flavour and odour deterioration, discolouration, destruction of nutrients and possible formation of toxic compounds. Inhibition of lipid oxidation is therefore necessary in order to maintain the sensory and nutritional quality of fish and fish products.

Antioxidants delay, control, or inhibit oxidation and deterioration of food quality (Shahidi, 2015). Synthetic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG), and tert-butylhydroquinone (TBHQ) have been used as primary antioxidants to arrest free radicals and control oxidation and off-flavour development. However, more recent interest has focused on studying natural antioxidants due to the toxicity and carcinogenic effects of some synthetic antioxidants (Shahidi, 2015; Wang, Zhao, & Wang, 2013).

To maintain the quality of seafoods and prevent microbial growth, freezing technology has been used for many decades. Although freezing or frozen storage is capable of preventing microbial spoilage, it cannot terminate chemical deteriorations, including protein denaturation and lipid oxidation in the products (Benjakul & Visessanguan, 2011). The consequences of protein oxidation have often been associated with loss of protein functionality such as gel-forming ability and water-holding capacity (Lund & Baron, 2010). Oxidation of lipids and proteins, especially during frozen storage, is associated with loss of quality of seafoods and their products. To alleviate or retard lipid oxidation and protein denaturation in seafood during the frozen storage, cryoprotectants have been widely used, especially in fish mince or surimi. Sucrose and sorbitol are the most commonly used cryoprotectants to maintain the quality of frozen fish products. However, they impart a sweet taste in the products which is not desirable to consumers (Cheung, Liceaga, & Li-Chan, 2009). Thus, alternative cryoprotectants with reduced sweetness have gained increasing attention in the seafood industry.

Recently, several studies have demonstrated that peptides derived after hydrolysis of food proteins, and specifically those produced from seafood processing by-products, act as potential antioxidants and have been isolated from different aquatic species (Aluko, 2015; Kim & Wijesekara, 2010; Olsen, Toppe, & Karunasagar, 2014; Pangestuti & Kim, 2013; Shahidi & Ambigaipalan, 2015). Therefore, seafood peptides with antioxidant activity may have great potential as safe alternatives to synthetic phenolics for the control of lipid deterioration in seafood products (Harnedy & FitzGerald, 2012; Mills, Stanton, Hill, & Ross, 2011). Furthermore, the cryoprotective effect of seafood peptides in different seafood systems such as myofibrillar proteins, surimi and fish mince during frozen storage or repeated freezing–thawing have been demonstrated. Peptides could effectively inhibit freeze-induced denaturation of muscle proteins comparable to that of commercial cryoprotectant, thereby signifying their potential as alternative cryoprotectants with the lower sweetness in seafood products. Therefore, seafood peptides can serve as the alternative safe natural additives with bifunctions, antioxidative and cryoprotective effects, which can be used for maintaining the quality of seafoods. Information regarding the sources of proteins and the methods used for production of seafood-derived peptides as well as the molecular characteristics, and mechanism of action of peptides is available (Harnedy & FitzGerald, 2012; Kim & Wijesekara, 2010; Samaranayaka & Li-Chan, 2011). However, the antioxidant properties of seafood peptides and potential application in seafoods have been demonstrated mostly in model food systems. This review describes seafood peptides with antioxidative and/or cryoprotective effects and the use of peptides with both of these functions in several seafood systems. In addition, the activity of pure peptides in real seafood matrix for their potential to prevent lipid oxidation and protein denaturation is discussed.

2. Seafood-derived peptides as bifunctional ingredients to control the oxidative deterioration of seafoods

The use of additives with both antioxidative and cryoprotective functions, especially in frozen fish or fish products, in which lipid oxidation and protein denaturation occur simultaneously is necessary to maintain the quality and sensory attributes. Seafood peptides can be used as bifunctional ingredients in seafood products to reduce oxidative reaction during the storage (Samaranayaka & Li-Chan, 2011). Several studies have shown that seafood protein hydrolysate and peptides could be used as both antioxidants and cryoprotectants (Harnedy & FitzGerald, 2012; Karnjanapratum & Benjakul, 2015; Nikoo, Benjakul, & Xu, 2015b), in which both lipid oxidation and protein denaturation can be retarded.